

DEVELOPING THE CAPACITY TO ASSESS POLICY PRIORITIES - ENGAGEMENT WITH STAKEHOLDERS AND MANAGERS

Mark A. Lovewell¹, Isaac C. Kaplan², Yvonne deReynier³, Mindi B. Sheer², Ruth Howell², Lisa Wooninck⁴, Joshua Lindsay⁵, Phillip S. Levin², Brian K. Wells⁶

1. West Coast Governors Alliance, Sea Grant
2. NOAA Fisheries, Northwest Fisheries Science Center
3. NOAA Fisheries, Northwest Regional Office
4. National Ocean Service, Office of National Marine Sanctuaries
5. NOAA Fisheries, Southwest Regional Office
6. NOAA Fisheries, Southwest Fisheries Science Center

OVERVIEW

Engagement with resource managers along the west coast began in 2010. Significant progress has been made with the Pacific Fishery Management Council and Monterey Bay National Marine Sanctuary identifying ways management considers ecosystem science and translates it into management actions and decisions.

INTRODUCTION

NOAA is primarily a science agency, although its research priorities are shaped by a host of laws that govern management of or consider human interactions with the natural world. A common theme in those laws is that, whether in predicting paths of hurricanes or protecting endangered species, the United States must strive toward, develop, and use the “best available” science tools and analyses. Integrated Ecosystem Assessments (IEAs) are, in part, an attempt by NOAA and its partners to develop next-generation science tools that expand how the best available science characterizes the relationships between species (including humans) within food webs and between those species and the physical world and its dynamic processes. In Levin et al. 2008, 2009, NOAA staff and colleagues first outlined the approach the agency hoped to take to IEAs, emphasizing roots in international efforts to frame the science-policy dialogue needed to implement ecosystem-based management (Caddy 1999, Sainsbury et al. 2000, Smith et al. 2007).

As envisioned in Levin et al. 2008, 2009, a first step in IEAs should be scoping, a process intended to identify management goals within a given ecosystem and the potential challenges or threats to achieving those goals. In de Reynier et al. (2010), NOAA staff explored the IEA scoping process in more detail, discussing the potential challenges of conducting a formal scoping process with a public and with managers unfamiliar with IEAs. To familiarize stakeholders and the public with the IEA concept, and to better engage scientists in discussions with other stakeholders, deReynier and colleagues recommended a basic first step of educating potential IEA users about the possibilities and limits of IEA science for a given ecosystem.

In 2011, NOAA released its first California Current IEA science products in a NOAA Technical Memorandum (Levin and Schwing 2011), largely intended to showcase the kinds of scientific analyses possible given available data, models, and technology. With this Technical Memorandum and with other agency staff publications on the California Current emerging, we were developing the scientific base to begin educating managers and the

public about the state of knowledge on drivers, pressures, and interactions within the California Current Ecosystem. Over 2011-2012, NOAA science staff have met with a host of entities to begin the California Current IEA (CCIEA) education process, engaging in forums including: the Pacific Fishery Management Council, the California Cooperative Oceanic Fisheries Investigations partnership, the NOAA Science Advisory Board, the Monterey Bay National Marine Sanctuary, Ecosystem Based Management Tools Network, and West Coast Governors Alliance on Ocean Health.

For 2012, CCIEA scientists developing management strategies for the California Current worked with 16 resource managers and stakeholders to identify:

- Drivers and pressures in the California Current
- Management options for coping with these drivers and pressures
- Metrics for success in addressing drivers and pressures.

In this context, pressures are human activities or natural processes that cause some impact on the condition of the ecosystem; drivers are forcing factors that result in pressures that in turn cause changes in the system; and metrics of success are the socially-determined measures by which policy makers or stakeholders judge whether they have reached their goals. We investigated drivers, pressures, management options, and performance metrics specifically to inform the Management Strategy Evaluation portion of the CCIEA, where a team of modelers applied a variety of models to evaluate possible futures for the California Current. These discussions between CCIEA scientists, managers, and other stakeholders do not constitute scoping. Instead, the discussions served as a test for how scientists might bring the perspectives of other stakeholders into the CCIEA science process to test different resource management strategies.

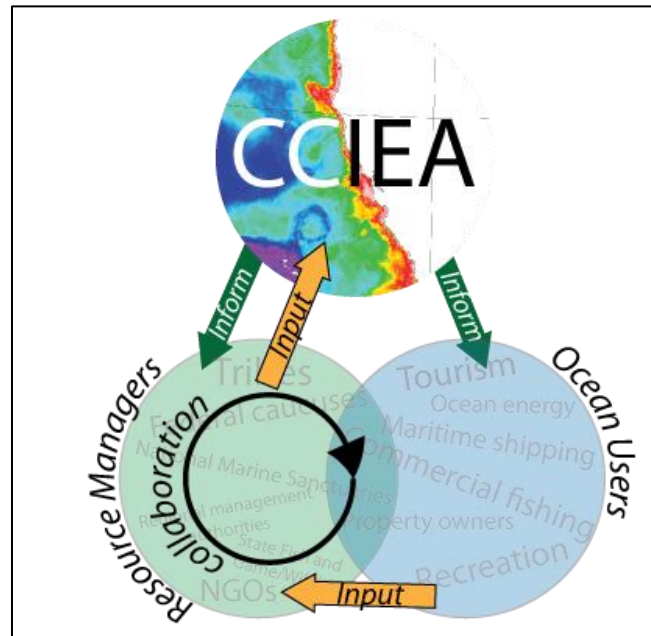


Figure EG1: CCIEA communication cycle

Although NOAA believes that scoping is essential to conducting a complete IEA, to developing tools for ecosystem-based management, and to assessing whether scientific products are bending toward “best available” science, the agency has no immediate plans to conduct broad public scoping in connection with the CCIEA. During 2012 discussions with managers and stakeholders, CCIEA scientists became aware that there is a host West Coast coastal and marine resource management processes already underway, many of which conduct regular scoping with their stakeholders. Rather than initiating a new scoping process, the agency plans to deepen its education and engagement efforts in 2013 so that its science products can become more responsive to existing resource conservation and management processes and mandates. As illustrated in Figure EG1, NOAA anticipates that developing the CCIEA will require ongoing communication efforts. Below, we discuss the 2011-2012 manager/stakeholder interview process used to develop and test the management strategy evaluations, and, we identify some of the regional science and management partnerships that could be useful in further assessing regional priorities for conserving and managing the California Current Ecosystem.

2011-2012 MANAGEMENT SCENARIO INTERVIEWS

We intended this initial set of interviews with managers and other stakeholders to inform ongoing science in 2012, rather than as a comprehensive overview of West Coast marine policy priorities. We identified interviewees based on their expertise with respect to the attributes of interest to 2012 CCIEA scientists: protected species, ecosystem integrity, fisheries, human communities, and habitat. We did not attempt a broad or representative survey, nor did we attempt to get a balanced amount of input for each of the attributes. In Box 1, we identify the affiliations of interviewees. These experts participated in interviews as individuals, not as representatives of opinions or policy stances of the organizations with which they were affiliated. In general, conversations focused on issues related to groundfish, salmon, marine mammals, and forage fish, with less focus on other

Box 1: Affiliations of CCIEA Manager/Stakeholder Interviewees

Northwest Indian Fisheries Commission

Monterey Bay Aquarium

California Fish and Game Commission

West Coast Seafood Processors Association

Washington Department of Natural Resources

Pacific Fishery Management Council

NOAA Fisheries’ Northwest Region

NOAA Fisheries’ Southwest Region

Natural Resources Consultants, Inc.

National Marine Sanctuaries

The Nature Conservancy

University of Washington

protected species, habitat and human communities. This set of issues likely reflects both the bias in our selection of experts, and the pressing management questions in 2012. Interviews were conducted by telephone in March 2012, were typically 30-60 minutes long, and involved only one expert at a time (one exception involved two people from a single non-governmental organization). Experts discussed topics that matched their areas of expertise and declined to discuss other topics. They identified main drivers and pressures, management options, and metrics of success. Drivers and pressures were discussed in the context of the next 10-30 years, except for issues related to climate change, which typically involved longer time frames. Experts listed drivers and pressures even in cases for which they were not aware of any related management options. Generally they were asked not to focus narrowly on particular quantitative methods (in the context of the CCIEA) that might eventually be applied to themes elicited here. The interviewees identified a broad set of drivers and pressures on the California Current ecosystem, including aspects not included as targets of management concern in the CCIEA (Fisheries, Protected Species, Habitat, Human Communities, and Ecological Integrity).

Below, the main themes from the 16 interviews are organized by category. The diagrams and related themes can be used in the context of the CCIEA to ask:

- What drivers and pressures may affect the California Current?
- What are impending management needs or mandates, related to current issues or future drivers and pressures?
- What existing or potential scientific and resource management tools can address these needs, drivers, and pressures?
- How can we test and judge new management strategies that could address these needs, drivers, and pressures (via either virtual testing or in the real world)?

In many cases these themes clearly involve drivers and pressures in the IEA terminology, but there is some blurring of language because the themes are taken from informal interviews. Note also that many of these drivers are not independent: for instance population growth is related to demands for energy and water, but since several experts discussed these topics separately, we have treated them separately here. We summarized conversation themes from the interviews into a set of five narrative (and graphical) scenarios, described in more detail below, focused on key drivers of the California Current:

- human population growth,
- climate change,
- conservation demands,

- energy crunch
- status quo

POPULATION GROWTH ISSUES

Human West Coast population growth was mentioned by experts primarily as a driver for freshwater and nearshore habitats, particularly for salmon – see Figure EG2. Experts directly involved in salmon management mentioned conflicts among water availability for salmon, agriculture, and urban populations. Summer was identified as a critical period, when water supplies were lowest and agricultural demand greatest. Three experts discussed the synergism between this water demand

and climate change, which is predicted to cause decreased snowpack and more acute water shortages in the summer.

Management actions that might mitigate these effects included decreased salmon harvest and potential changes in dam water management. One such change in water management would be to reduce intentional spills of water during the winter, which are typically conducted to leave capacity in reservoirs for flood control. Reduced winter spills would lead to increased reservoir retention of water into drier periods of the year, but with the risk of potential winter flood damage. Other potential impacts of West Coast population growth included additional ship-based and terrestrial pollution, and increased need for energy infrastructure, but details of the scope and severity of these were generally outside the expertise of the selected experts.

State and federal managers discussed increased seafood demand due to global population growth and rising affluence of global consumers, particularly in Asia. Managers particularly cited export of Dungeness crab to China as one recent development, as well as strong markets for octopus, geoducks (*Panopea generosa*), live rockfish (*Sebastes* spp.), and hagfish (*Eptatretus* spp.). Harvest of species such as geoducks requires gears that are potentially damaging to habitat; harvest of live rockfish focuses on different size and age classes than trawl gears. Countering the trend for increased demand for wild-caught West Coast fish, increased global aquaculture and imports to the US reduce demand for low-value whitefish such as Dover sole

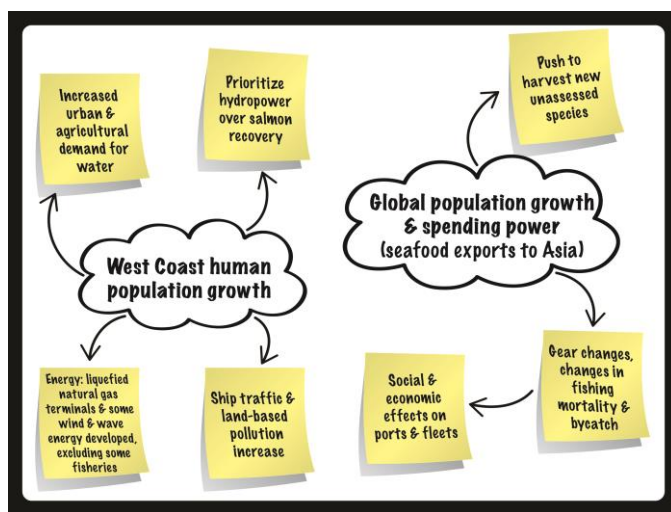


Figure EG2: Population growth scenario issues

(*Microstomus pacificus*). Comparison of the environmental cost of imported aquaculture-raised seafood versus locally caught seafood was raised as a potential research topic. Federal managers were generally confident that safeguards were in place to prevent rapid development and overexploitation of new species; however several of the new nearshore target species are managed by state agencies.

CLIMATE CHANGE ISSUES

The majority of experts (13 of 16) discussed threats to the California Current from climate change and ocean acidification, typically focusing on timescales of several decades or more – see Figure EG3. Salmon (*Oncorhynchus* spp.) were a common focus due to potential changes in streamflow (warmer winters and less snowpack), which could impact stream-type fish such as spring Chinook. Potential northward shifts of the southern

extent of salmon ranges were listed as one threat to California and Oregon salmon populations. Additionally, the vulnerability of salmon prey, such as pteropods, to ocean acidification was listed as one potential effect that could lead to declines in salmon abundance. Potential climate change effects for other marine species included increased frequency of shifts between sardine (*Sardinops sagax*) and anchovy (*Engraulis mordax*) abundance, and northward shifts in ranges for sardine and hake. Two experts mentioned that the effects on species distribution and productivity caused by warming, acidification, and hypoxia were likely to be spatially patchy, as well as varying by latitude, and therefore the economic impacts would differ between ports.

Very few specific policy actions were mentioned by experts in relation to climate change and ocean acidification. The primary sentiment from experts was that they would assess climate change impacts through existing monitoring programs; reductions in harvest were often mentioned as the policy response. Two salmon managers identified habitat restoration in streams as a method to mitigate climate change. Several experts pointed out the high degree of uncertainty regarding the exact long-term implications of climate change and acidification. One expert felt that overall the link between climate phenomena (such as El Niño-Southern

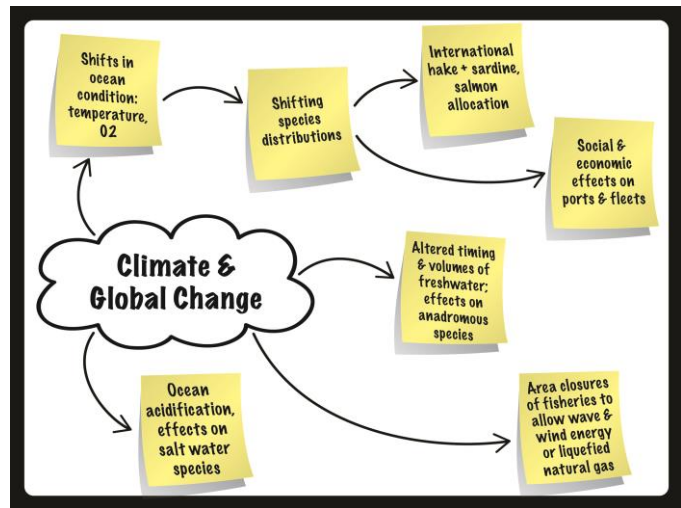


Figure EG3: Climate change scenario issues

Oscillation and the Pacific Decadal Oscillation) and marine communities was poorly understood, and improved understanding of these phenomena was a necessary step to scientifically addressing trends in global change. Two experts identified increased community-based management, monitoring, and allocation, as methods to identify and manage for spatially patchy effects of climate change. These two experts suggested that community-based management at the scale of ports or clusters of nearby ports could respond to localized changes in ocean conditions. Though most of the 16 interviews focused on local management actions related to fisheries, respondents also mentioned potential shifts in national energy policy, such as development of alternative energy and liquefied natural gas facilities.

CONSERVATION DEMAND ISSUES

Twelve of 16 experts discussed potential management actions and consumer choices that aim to protect or recover particular species or ecosystem components – see Figure EG4.

Potential conservation management actions included increased “set-asides” for forage fish (thresholds of abundance below which harvest is prohibited).

Increasing these thresholds might increase the availability of forage for marine mammals, birds, and other predators. Adoption of catch shares (individual transferable quotas) for additional fisheries was discussed as one means to reduce bycatch and prevent catches from exceeding quotas, as well as to increase profitability.

Development of regional community-based management was stated as one method to improve data collection and flexible management responses aimed at conserving marine stocks. Conservation actions to increase abundance of salmon included harvest reductions and time/area closures, as well as additional and ongoing dam removal (for example, in the Elwha River). Ship strikes of marine mammals and entanglement of marine mammals, birds, and turtles in fishing gear were mentioned by several experts as motivation for potential spatial management actions. Five experts stated that there major scientific gaps in understanding forage needs for killer whales, and the impact of forage species harvest on the rest of the food web. They noted the need to identify key forage species, concerns regarding local depletion of forage species

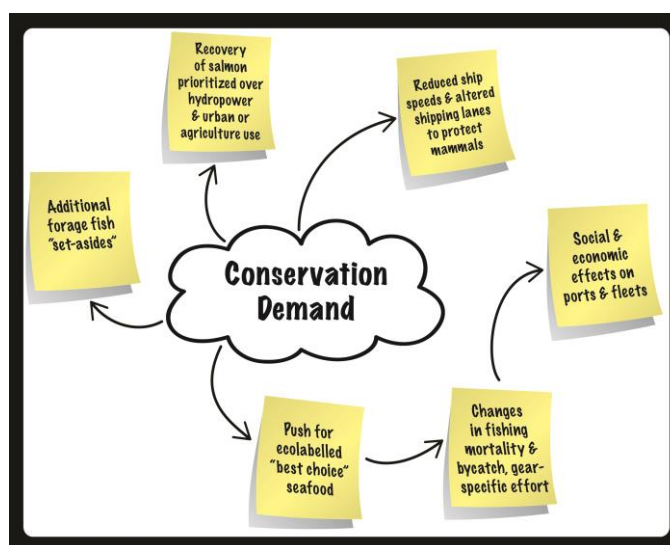


Figure EG4: Increased demand for conservation scenario issues

(sardine or squid) by fisheries near seabird or seal rookeries, and a need to quantify the economic value of forage species consumed by harvested predators.

Policy developments likely to lead to further conservation actions included implementation of Ocean Commission recommendations and the National Ocean Policy, regional governance efforts such as the West Coast Governors Alliance, and spatial planning within state waters. One manager felt that improved coastal and marine spatial planning (CMSP) was likely to resolve many spatial conflicts between fishing, shipping, and conservation needs; others felt that whether CMSP was likely to develop in each state depended on the local management and political climate.

Experts expressed mixed views on the impact of seafood eco-labeling (e.g. certification or rankings of sustainability) and the preference for local seafood. Salmon fisheries with strong exports to Europe were cited as a case where eco-labeling was likely to alter both prices and fishery practices, since-European markets were said to generally respond positively to eco-labeled products. One expert pointed out that there are many eco-labeling schemes available to the industry, with a variety of standards. A second expert pointed out that consumers were demanding higher quality seafood, but not necessarily eco-labeled or local fish. A contrasting observation was that there is increased demand for locally caught, high-value fish such as swordfish and albacore. NOAA FishWatch, a consumer seafood education website, was identified as one alternative to eco-labeling schemes.

ENERGY CRUNCH ISSUES

Future increases in price of diesel fuel were generally predicted to lead to changes in fishing fleet operations, and increased establishment of energy facilities (wind, wave, or liquefied natural gas) were stated as likely to lead to reductions in fishing areas near such facilities – see Figure EG5. Most experts assumed some future increase in fuel price for fishing vessels. Two stakeholders also mentioned the high fuel demand involved in processing and transporting fish, narrowing profit margins, and the negative impact that gasoline prices have on consumer demand for seafood. Trawl, albacore troll, mackerel purse seine, and recreational fleets were identified as being fuel intensive or sensitive to fuel price. Salmon experts mentioned ongoing tradeoffs between hydropower and salmon, but also did not foresee reduced protections for salmon under the Endangered Species Act.

Wave energy facilities were identified as a policy response to the energy crunch, and experts cited new pilot projects near Reedsport and Newport, Oregon. Potential impacts from these could include acoustic (sound) impacts on marine mammals. Fisheries could be directly

affected if they were excluded from operating near wave energy facilities. Wave, wind, and LNG facilities were mentioned by three respondents as potentially having ecological effects similar to marine protected areas, including local increases in abundance of fish and demersal species.

Finally, experts considered potential changes to shipping traffic in relation to increased energy prices. This was discussed in terms of increased shipping as industries push for low-cost methods (freighters, tankers) to move goods. Additional increases in West Coast marine traffic could stem from tanker transport of Canadian crude oil from Pacific Northwest ports. Expansion of the Panama Canal was also discussed as

likely to restructure West Coast shipping patterns, allowing more direct shipping from Asia to the U.S. East Coast rather than to West Coast shipping terminals. Potential management actions to mitigate the effects of shipping on marine mammals included reduced ship speeds and altered shipping lanes.

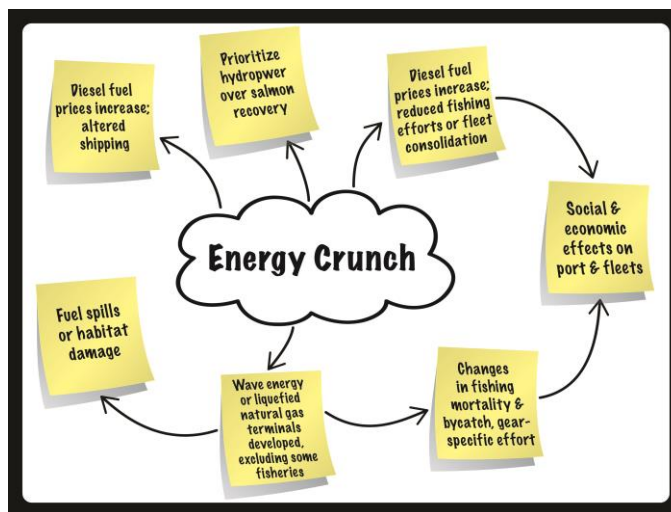


Figure EG5: Energy crunch scenario issues

STATUS QUO MANAGEMENT ISSUES

Comments about Status Quo management primarily addressed challenges within the existing management process, and issues relate to the groundfish catch shares program that was implemented in January 2011 – see Figure EG6. Lengthy multi-year review processes and lags between data collection and fishery management actions were identified as one impediment to rapid, flexible responses to shifting stock abundances. Two respondents also pointed out that many fishery restrictions on groundfish gear specifications and areas fished (e.g. Rockfish Conservation Areas) may now be counterproductive under a catch share program that aims to foster innovation and incentives for individual vessels to reduce bycatch. The high costs of management, monitoring, and assessment were identified as one factor that may limit the continued operation of some less economically viable fisheries in the future.

The implications of the groundfish catch share program for fisheries and marine species were discussed by eight of the 16 experts. These managers and stakeholders were aware of quota that was not being harvested, primarily for flatfish, due to constraining bycatch of rockfish. Opinion differed on whether those flatfish quotas might be met via the catch shares system. One expert stated that there was unlikely to ever be sufficient demand; another said that deeper water species might be targeted more effectively, but that nearshore species could not be targeted without exceeding rockfish bycatch quotas. One alternate opinion was that new midwater rockfish fisheries, targeting widow (*S. entomelas*) and yellowtail rockfish (*S. flavidus*), might evolve as fishers improve their targeting precision. This would shift these two species from being avoided bycatch to being actively targeted. Two experts discussed the formation of risk pools being formed between fishermen, to pool the limited quotas of bycatch species such as rockfish. Such risk pools could reduce the likelihood that any single fisherman would be forced out of the fishery by unexpectedly high catches of bycatch species. Economic implications of the groundfish catch share program were mentioned by three experts, including potential fleet consolidation (reductions in number of vessels) and subsequent changes in fishing location and port utilization, changes in infrastructure, or potential movement of some vessels into open access fisheries. The potential for quota shares to be used as collateral was mentioned as one potential factor contributing to reinvestment in the fishery. Such reinvestment might lead to more fuel efficient vessels, since many groundfish vessels are over 20 years old and might be replaced. The main management action invoked to address challenges with the catch share fishery was flexibility in gears and areas fished, consistent with the individual incentives offered to fishers under the catch share program.

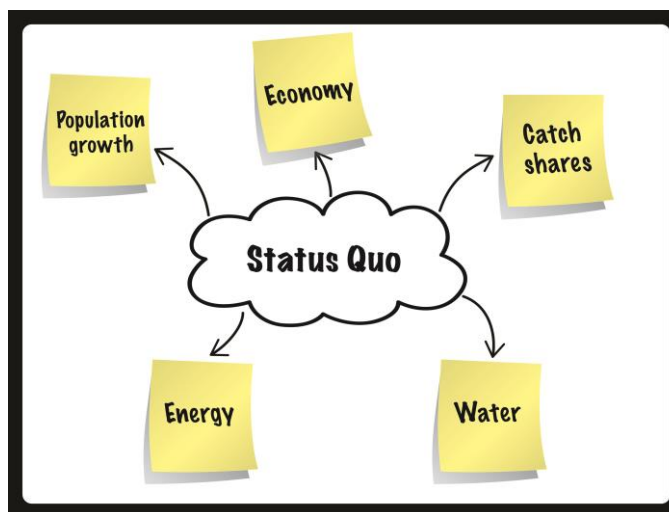


Figure EG6: Status quo scenario issues

2011-2012 INTERVIEW SYNTHESIS

The interviewees identified both formal and informal measures of success for future management programs, but tended to focus on management of fish and marine mammals. For instance, metrics of success for marine fisheries included landed value, profitability, and

rebuilding progress of overfished species. Practical goals included “no one going broke”, “no unhappy political constituents”, having a “responsive and coherent fishery management plan that is producing the expected results”, and “profitable fisheries that allow fishermen to invest in the industry and engage in management and sustainability.” Metrics of success for salmon were primarily those defined in salmon recovery plans (Viable Salmonid Population parameters), related to abundance, population growth rate, population spatial structure, and diversity. Access to the fishery was also stated as a metric of success, in terms of number of recreational angler trips and active commercial licenses. For marine mammal management, the number of strandings was mentioned as one metric, as were population growth rates, mortality relative to potential biological removals, and the economic value of whale watching. More comprehensive metrics of economic and ecological success included the number of jobs in fishing sectors, the health of seafood consumed locally for subsistence, and the ability to keep pollution concentrations below allowable levels to ensure subsistence consumption. Perhaps reflecting the expertise of this set of managers and stakeholders, most of the metrics of success focused on wild fisheries and marine mammals (protected species). Other ecosystem components such as habitat, ecosystem integrity, human communities (aside from economics) and protected species (beyond mammals) were not emphasized.

The responses and themes from these interviews are not novel. In fact, in many cases experts suggested that they were simply communicating “common knowledge”. However, the breadth of experience from these 16 experts allows a somewhat synoptic view of current drivers, pressures, and management concerns in the region, and this is likely greater than that of any individual. Additionally, specific concerns raised in the interviews involve key details that can guide future research, which necessarily must move beyond broad-brush trends. For instance, climate change was suggested to have potentially strong effects specifically for spring-run Chinook salmon; pelagic mackerel and tuna fleets were identified as likely to be most sensitive to fuel prices; markets for Dungeness crab were linked specifically to rising Chinese import demand. Such details are essential for identifying and prioritizing future scientific analyses and ecological and economic monitoring.

These interviews provided motivation for the Management Strategy Evaluation portion of the 2012 and 2013 California Current Integrated Ecosystem Assessment. In the management strategy evaluation portion of the IEA we incorporate these themes into scenario narratives on population change, climate change, conservation demands, energy crunch, and evolution of status quo management. We then apply quantitative tools that allow us to investigate how some pressures affect attributes of interest for the IEA. Future outreach efforts will also continue to

guide research related to risk assessment, status and trends of ecosystem components, and ecosystem drivers and pressures.

2013 AND BEYOND: ENGAGEMENT WITH CALIFORNIA CURRENT STAKEHOLDERS AND MANAGEMENT PROCESSES

In support of the CCIEA, NOAA will be continuing to engage with California Current Ecosystem stakeholders and management processes in 2013 and beyond. Our intent is to: 1) educate a larger audience on the capabilities and potential value of an IEA approach, 2) expand the range of stakeholder input incorporated in the CCIEA, and 3) build on the success of preliminary manager engagement by maintaining an ongoing dialogue between IEA scientists and other stakeholders. We plan to collaborate with multiple organizations, including the West Coast Governors Alliance on Ocean Health (WCGA) and West Coast EBM Network, to share resources and strengthen partnerships across and within governmental and non-governmental agencies.

To broaden our education efforts, we have launched a website on IEA work to date, and are developing webinars and other presentations for IEA outreach. Webinars began in fall 2012 and address: why IEAs can be useful to understanding ecosystem interactions, what science products are emerging from the California Current IEA, and the data and methods used to generate IEA science; how to engage with the IEA process. We are conducting webinars both to open new and to advance existing relationships with groups interested in the California Current and natural resource management. In 2013 and beyond, we plan to use webinars to share IEA science products and engage with:

- Internal NOAA staff
- WCGA IEA Action Coordination Team
- West Coast EBM Network
- West Coast Sanctuary Advisory Councils
- West Coast NGOs
- Tribal Groups
- Federal Caucuses (Columbia River, Bay Delta, Puget Sound)

Beyond webinars and other presentations to interested managers, stakeholder groups and the public, NOAA also plans to build on 2011-2012 manager/stakeholder interviews with a more broad-based questionnaire and targeted interviews intended to elicit public values for the California Current. The questionnaire is intended to help IEA scientists better sort through drivers and pressures within the California Current by soliciting more information and opinions

on those drivers and pressures, and on potentially useful indicators of ecosystem status and ecosystem-based management strategies. Issues to be addressed with the questionnaire include:

- What are current regional resource management priorities?
- Are there geographic regions within the larger California Current are of particular interest and relevance to managers and other stakeholders?
- What management strategies are available under current legal authorities and funding constraints (what is on or off the table)?
- What are hurdles to achieving management goals (data limitations, bureaucratic, procedural, e.g.)?
- How do stakeholders measure management success (indicators - why a specific indicator? can you make a decision based on it? are there threshold values?)
- What indicators do resource managers use to make decisions on a monthly/annual basis?
- Current drivers and pressures (aquaculture, ocean energy, fishing, e.g.), and potential for interacting or cumulative impacts
- What are the best strategies for facilitating cooperative management between and among sectors?

We plan to make the questionnaire available online and distribute it through networks within NOAA and through NOAA partners. Information gathered through this process will be available to IEA scientists as reference for future IEA work.

Undertaking an ecosystem assessment for such a large region, encompassing thousands of jurisdictional boundaries and priorities, is an iterative and lengthy process, whether in development of defensible science products and processes, or in building relationships to allow policy expertise to enhance and inform the science process. Regional natural resource management and marine policy efforts have already established networks with stakeholders across multiple sectors, and have expertise and a mandated forum for stakeholder engagement. Members of NOAA's CCIEA group, who are primarily of biologists and ecologists, do not often interact with the cross-sectoral stakeholder community, which is why building relationships with other stakeholders is essential if CCIEA scientists are to conduct work useful to management processes. For these reasons, NOAA's CCIEA process will eschew scoping solely in support of the IEA, and instead focus more on using information already scoped through public policy processes, or on tuning scientific products so that they more directly address questions from or issues under consideration by existing public policy processes.

LITERATURE CITED

- Caddy, J. F. 1999. Fisheries management in the twenty-first century: will new paradigms apply? *Reviews in Fish Biology and Fisheries* **9**:1-43.
- DeReynier, Y. L., P. S. Levin, and N. L. Shoji. 2010. Bringing stakeholders, scientists, and managers together through an integrated ecosystem assessment process. *Marine Policy* **34**:534-540.
- Levin, P. S. and F. B. Schwing. 2011. Technical background for an integrated ecosystem assessment of the California Current: Groundfish, salmon, green sturgeon, and ecosystem health. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-109, 330 p.
- Sainsbury, K. J., A. E. Punt, and A. D. M. Smith. 2000. Design of operational management strategies for achieving fishery ecosystem objectives. *ICES Journal of Marine Science: Journal du Conseil* **57**:731-741.
- Smith, A. D. M., E. J. Fulton, A. J. Hobday, D. C. Smith, and P. Shoulder. 2007. Scientific tools to support the practical implementation of ecosystem-based fisheries management. *ICES Journal of Marine Science* **64**:633-639.